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Status of Striped Bass (*Morone saxatilis*) in the Southern Gulf of St. Lawrence in 1999 and 2000

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ABSTRACT

The size of the southern Gulf of St. Lawrence striped bass population in 1999 and 2000 was estimated based on mark-recapture experiments using bycatch data from the commercial gaspereau fishery of the Northwest Miramichi River. The most probable population size, generated by a Bayes algorithm was 3940 and 3900 for 1999 and 2000 respectively. Male striped bass comprised 69% of the population in 1999 and 64% in 2000. Trends in catch per unit of effort (catch/trap/day) for 1999 and 2000 were similar to other years when the population has been estimated to be less than 10,000 fish. NW Miramichi striped bass achieved a maximum of 24% of the conservation requirement in 1999 and 28% in 2000. This makes the fifth year in a row that the provisional conservation requirement has not been met. Recruitment of three-year-old males in 2000 was poor and four-year old females in 2001 is likely to be similar. The NW Miramichi striped bass population is heavily dependent upon the contribution of the 1996 year-class. The 1999 year-class is large bodied and have had good survival which is encouraging for recruitment in 2002-03. With the continued closure of commercial and recreational fisheries, and allocations to First Nations suspended, southern Gulf striped bass are under maximum management protection. A precautionary approach is warranted for southern Gulf of St. Lawrence striped bass.

RÉSUMÉ

L'effectif de la population de bar rayé dans le sud du golfe du Saint-Laurent en 1999 et en 2000 a été estimé au moyen d'expériences de marquage et de recapture en se basant sur des données provenant des prises accidentelles de bar rayé de la pêche commerciale du gaspareau dans la rivière Miramichi Nord-Ouest. Le niveau de population le plus probable, généré par l'algorithme de Bayes, était de 3940 et 3900 pour 1999 et 2000 respectivement. Les mâles représentaient 69% de la population de bar rayé en 1999, et 64% en 2000. Les tendances au niveau des prises par unité d'effort (prises par casier par jour) pour 1999 et 2000 étaient semblables aux tendances des années antérieures, alors que la population était estimée à moins de 10 000 poissons. Le bar rayé de la Miramichi Nord-Ouest a atteint au maximum 24% des exigences en matière de conservation en 1999 et 28% en 2000, et porte à cinq ans, le nombre d'années consécutives sans obtention du seuil des impératifs de conservation provisoires. Le recrutement des mâles de trois ans en 2000 était faible et le recrutement des femelles de quatre ans devrait être faible également en 2001. La population de bar rayé de la Miramichi Nord-Ouest dépend grandement de la contribution de la classe d'âge de 1996. La classe d'âge de 1999 est importante et présente un excellent taux de survie, ce qui est encourageant pour le recrutement de 2002-2003. Compte tenu du maintien de l'interdiction des pêches commerciale et récréative, et de la suspension des allocations aux Premières nations, le stock de bar rayé du sud du golfe jouit du maximum de protection sur le plan de la gestion. On préconise la prudence pour ce qui est de la gestion du stock de bar rayé du sud du golfe du Saint-Laurent.

SUMMARY SHEET

STOCK: Southern Gulf of St. Lawrence Striped Bass

PROVISIONAL CONSERVATION REQUIREMENT: 5000 female spawners

Year	1993	1994	1995	1996	1997	1998	1999	2000
Population Estimate								
Total spawners (mode)	5500	29000	50000	8090	8000	3400	3940	3900
95% confidence limit (lower)	4550	23000	35000	6275	5800	2900	3450	2850
95% confidence limit (upper)	7300	47000	175000	13370	17500	4800	4430	5250
Proportion mature males	0.94	0.92	0.63	0.37	0.69	0.83	0.69	0.64
Proportion mature females (minimum)	na	na	na	na	na	na	0.03	0.04
Proportion mature females (maximum)	0.06	0.08	0.37	0.63	0.31	0.17	0.31	0.36
Mature males (minimum)	5170	26680	31500	2993	5500	2822	2719	2496
Mature females (minimum)	na	na	na	na	na	na	118	156
Mature females (maximum)	330	2320	18500	5097	2500	578	1221	1404
Mature females (minimum % conservation requirement met)	na	na	na	na	na	na	2	3
Mature females (maximum % conservation requirement met)	7	46	370	102	50	12	24	28
Catch Data								
Stratum (days)	16	19	20	18	13	25	22	23
Traps per stratum	13	13	13	13	13	13	13	13
Traps sampled	46	50	64	72	60	83	139	102
Traps fished during season	208	247	260	212	156	248	297	220
Mean catch/trap/day **(season)**	1.7	30.9	12.0	6.4	3.0	3.5	2.3	4.7
Juvenile Striped Bass								
Median catch per trap per day	17	7	255	452	10	44	na	na

INTRODUCTION

The Northwest (NW) Miramichi River flows easterly into the southern Gulf of St. Lawrence (southern Gulf) (Figure 1) and is the principal spawning site for striped bass in the southern Gulf (Bradford et al. 1995; Robichaud-LeBlanc et al. 1996). The NW Miramichi River striped bass spawning stock currently represents the northern most self-sustaining population of striped bass in North America. The only other remaining spawning population of striped bass in the Maritimes exists in the Bay of Fundy and is considered to be genetically distinct from the Gulf of St. Lawrence population (Wirgin et al. 1993; Robinson 2000). NW Miramichi striped bass are managed as a single spawning population in the Gulf of St. Lawrence.

NW Miramichi striped bass enter the Miramichi estuary in early May and are known to frequent river mouths during their ascent to the spawning grounds (Bradford et al. 1995). Spawning generally occurs over a few days (1-2 weeks) in late May and early June. After spawning, adults return to a summer coastal migration, ranging from Percé, Québec to the Margaree River, Cape Breton (Bradford and Chaput 1996). Pelagic larvae develop quickly and move inshore to warm, shallow habitats where they grow rapidly during the summer (Robichaud-LeBlanc et al. 1998). Young-of-the-year (YOY) exhibit a down-river range extension during the summer months (Robichaud-LeBlanc 1998) and have been collected as far south as the Kouchibouguac, and Richibucto estuaries (Robinson 2000). The majority of male striped bass mature at three years of age, one year earlier than females. Adults appear to re-enter southern Gulf estuaries opportunistically to overwinter.

Striped bass are intercepted as bycatch in three fixed-gear commercial fisheries in the Miramichi system. Primarily adults are captured in trapnets of the alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) (collectively gaspereau) fishery, young-of-the-year in fyke nets of the American eel (*Anguilla rostrata*) fishery, and young-of-the-year in box or bag nets of the Rainbow smelt (*Osmerus mordax*) fishery. Bycatch sampling of these fisheries was initiated in 1991 (Hanson and Courtenay 1995) and sampling of some or all of these fisheries remained the basis for previous stock assessments. The stock assessment for southern Gulf of St. Lawrence striped bass in 1999 and 2000 was no different.

Stock assessments conducted for NW Miramichi striped bass each year since 1993 (Bradford et al. 1995; Bradford and Chaput 1996, 1997, 1998; Bradford et al. 2001) reveal that this population exhibits large annual fluctuations in abundance (high of 50,000 in 1995 to a present low of approximately 3,000 - 5,000 fish). The categorization of southern Gulf of St. Lawrence striped bass as reduced or declining in 1990 (Chaput and Randall 1990) was maintained until the last assessment completed in 1998 (Bradford et al. 2001).

The objectives of this assessment were:

1) To estimate the number of spawners participating in the 1999 and 2000 spawning seasons;
2) To evaluate the conservation requirement currently used for southern Gulf striped bass and to examine alternative reference points;
3) To relate the number of spawners to the provisional conservation requirement;
4) To examine the validity of adult striped bass bycatch (CPUE) in the commercial gaspereau fishery of the NW Miramichi as an alternative indicator of status, and
5) To evaluate trends in biological characteristics and population size.

DESCRIPTION OF FISHERIES

Commercial

Commercial harvesting of southern Gulf striped bass was closed permanently in March of 1996. Bradford and Chaput (1996) reported commercial harvests of striped bass by statistical district and by month for years 1917 to 1995 for the southern Gulf of St. Lawrence. The bycatch tolerance for fish < 35 cm total length in the smelt and gaspereau fisheries was amended in 1998 so that any sized striped bass intercepted in any commercial gear must be returned to the water unharmed. Sale of wild striped bass from the southern Gulf of St. Lawrence is prohibited.

Tags returned (n = 2) by fishery observers in the spring of 1997 from herring nets off of Escuminac, NB (Bradford and Chaput 1998), indicate that striped bass are susceptible to other fisheries than fixed-gear fisheries of southern Gulf of St. Lawrence estuaries.

First Nations

First Nation Peoples harvested southern Gulf striped bass for food social and ceremonial purposes from July 1 to October 31 in 1999 and 2000. Because gillnets are not selective in terms of the size of striped bass caught, size restrictions were lifted in 1996 and the harvest is managed on the basis of total catch. None of the First Nations reported striped bass harvests in 1999 or 2000 (Table 1).

Recreational

Minimal recreational angling data for southern Gulf striped bass has been, or is collected on a regular basis. Bradford et al. (1995) and Bradford and Chaput (1996) summarized striped bass angling data before new management restrictions (season, size, and bag limit) were introduced in 1993-94. In 1999, anglers were permitted to hook and release striped bass between April 15 and October 31, while in 2000, inland and coastal Gulf of St. Lawrence waters were closed to recreational striped bass angling (i.e. no directed hook and release angling was permitted).

CONSERVATION REQUIREMENT

A provisional conservation requirement of 5000 female spawners was introduced in 1996 (Bradford and Chaput 1997) for NW Miramichi striped bass. The concept for the spawning requirement was that when spawning females numbered in excess of 5000, a several fold increase in young-of-the-year was apparent (years 1995-96 Bradford and Chaput 1996, 1997).

The number of female spawners may not be the determining factor for striped bass production in the Gulf of St. Lawrence. Numerous studies with US populations report that recruitment is controlled by exogenous, density-independent factors (Ulanowicz and Polgar 1980; Rutherford and Houde 1995; Rutherford et al. 1997; Bulak et al. 1997). Monitoring of environmental variables on spatial and temporal scales may be useful when developing stock-recruitment indices for southern Gulf of St. Lawrence striped bass.

A spawner per recruit (SPR) analysis was conducted based on assumed biological characteristics of striped bass for the southern Gulf of St. Lawrence. Maximum age was set at 11 years. Relative fecundity was assumed to be similar to the fecundity at age relationship of Paramore (1998) which has a lower fecundity at age than that used by Goodyear and Christensen (1984) (Figure 2). The partial recruitment vector (PR vector) to the fishery was assumed to be very steep with 50% at age three and 100% for ages four and older (Figure 2). The analysis was conducted by varying natural mortality (M) values between 0.05 and 0.45, constant for all fish aged three years and older. In the eastern US, M is assumed to be 0.15. The %SPR was estimated for variable M and the reference points calculated were 30% and 50% SPR as suggested by ICES (1997). The results suggest that the limit fishing mortality rate (F_{lim}) would be between 0.19 and 0.28 (Figure 2). The precautionary fishing mortality rate (F_{pa} at 50% SPR) would be between 0.11 and 0.15 (Figure 2). At an assumed M of 0.15, F_{lim} and F_{pa} would equal 0.21 and 0.11 respectively.

RESEARCH DATA

Mark-Recapture Experiments in 1999

Adult striped bass are known to enter the Napan River one to two weeks prior to their arrival on the spawning grounds of the NW Miramichi (Bradford et al. 1995). One commercial fisherman in the Napan River was contracted to operate two trapnets before the beginning of the gaspereau season to mark adult striped bass. Tagging of striped bass in the Napan River for the mark-recapture experiment was initiated in 1996 in an effort to separate the marking and recapture sites in time and space (Bradford and Chaput 1997; 1998). The distance between the marking site (Napan River) and the recapture site (NW Miramichi) is some 25-30-river kilometres (Figure 1), which should result in complete randomisation of tags throughout the population.

In 1999, striped bass were tagged on 6 occasions (two-day intervals) in the Napan River from May 11 to May 21 (Table 2). Adult striped bass > 32.5 cm forklength (FL) were tagged with individually numbered, yellow T-bar tags, inserted between the first two spines of the anterior dorsal fin. Recaptured tags from previous years (n = 8) were included in the pool of tagged fish from the Napan River. All striped bass captured in both Napan River trapnets were sampled for forklength (nearest mm), sexed based on external characters, scale sampled for later aging, and released to the wild.

Adult striped bass were also tagged on one occasion (May 21) at two trapnets in the NW Miramichi River (the only two fishing on this date) (Table 2). This tagging event marked the first two trapnet checks of the 1999 gaspereau season. The commercial fisherman was paid $1.00 per striped bass tagged. Recaptured tags from previous years observed throughout the gaspereau season (n = 14) were included in the pool of tagged fish from the NW Miramichi River. Striped bass were sampled similarly to those captured in the Napan River.

The final group of tags was placed on striped bass at a Department of Fisheries and Oceans (DFO) science index trapnet located at Hackett's Beach on the Northwest Miramichi between May 6 and May 24 (Table 2; Figure 1). This trapnet was fishing for Atlantic salmon smolts but also intercepted striped bass. Striped bass were sampled similarly to those at the other marking locations.

The commercial gaspereau trapnets of the NW Miramichi were used as the recapture site for all three pools of tagged fish. Effort (both the number of traps fishing and the number of days the traps were fishing) for this fishery is highly variable and often depends on the amount of gaspereau running. Thus, on any given day of the gaspereau season, any number of the 13 trapnets can be fished. As many trapnets as possible (1 to 11) were visited daily throughout the 1999 gaspereau season. Adult striped bass total catches were enumerated and searched for tags. Tagged striped bass that came on board when the sampler was present were released after recording the tag number and sex. When the sampler was not present during fishing, fishermen removed tags from fish and rendered them to the sampler at the end of the day. For the purpose of the mark-recapture experiments, these tags were subtracted from the appropriate pool of tags available for recapture in subsequent days. A $4.00 reward was paid for recaptured tags that included catch information. Scale samples for later aging were collected opportunistically throughout the gaspereau season. The sex of all striped bass from sampled catches was checked.

Mark-Recapture Experiment in 2000

Tags were placed on adult striped bass between May 25 and May 30 at six commercial gaspereau trapnets in the NW Miramichi River (Table 2). Tagging locations depended solely on which trapnets were fishing at the beginning of the season. The amount of $1.50 per bass tagged at a trapnet was paid to NW Miramichi commercial fishermen. Previous year recaptures observed throughout the course of the gaspereau season (n = 49) were added to the NW Miramichi pool of tagged fish.

The recapture phase of the experiment was as in previous assessments using the 13 gaspereau traps of the NW Miramichi as the recapture sites. As many trapnets as possible were visited daily (one to seven) throughout the 2000 gaspereau season. Adult striped bass total catches were enumerated and searched for tags. Tagged striped bass that came on board when the sampler was present were released after recording the tag number and sex A recapture reward was not offered in 2000 and fishermen were therefore asked not to remove tags. Fishermen were paid $1.00 for any adult bass that came on board when the sampler was present (regardless of tag status). Although efforts were made to distribute sampling effort evenly to all trapnets, timing of trapnet fishing always determined which trapnets would be sampled. All striped bass of sampled catches were measured for forklength (nearest mm), sexed based on external characters, and released to the wild. Scale samples for aging were collected opportunistically throughout the gaspereau season.

Beach Seine Survey 2000

A beach seine survey of the southern Gulf of St. Lawrence was conducted in 2000 to identify the distribution of YOY striped bass outside of the Miramichi estuary. Similar to many US agencies (ASMFC 1989; Versar 1988), an annual beach seine survey may be useful as an index of spawner success once several years of data have been collected.

Beach seine sites were distributed throughout much of the southern Gulf of St. Lawrence from the Tracadie River (most northern) to the Shediac River (most southern). Data recorded included total catch of striped bass, area sampled, water temperature, status of the tide, direction of sweep, and maximum depth. Striped bass were measured for fork and total length (nearest 1 mm), and weight (nearest 0.1 g).

Biological Characteristics in 1999

Sexes of striped bass (male, female) were only identified for fish that were ripe enough to expel sexual fluids (milt, eggs). Adult striped bass that did not expel sexual fluids before or after spawning were identified as sex unknown and unknown spent respectively. The majority (minimum of 69%) of striped bass sampled throughout the 1999 mark-recapture experiments were male (Table 3). The high incidence of striped bass identified as sex unknown, require that male to female sex ratios be considered minimum values (Table 3). Striped bass positively identified as female were few in 1999 (Table 3).

Sex ratios in 1999 differed in time and space. Male composition shifted from 58% in the Napan River to well over 70% on the spawning grounds of the NW Miramichi (Table 3). These data indicate that many striped bass progress to a ripened state between the time they enter the Miramichi estuary and the time they arrive on the spawning grounds. In addition, young (primarily 3 year old) male striped bass are known to "hang around" for the entire gaspereau season, even after the major spawning event(s) are complete. Male behaviour such as this could alter the sex ratios observed over the course of the study.

It is important to note that a high percentage (42%) of adult striped bass sampled in the Napan River before they reached the spawning grounds was identified as sex unknown. Over the course of the study, 48 fish tagged in the Napan River as sex unknown were recaptured in a ripened state on the spawning grounds. Eighty-eight percent of these fish ripened as males, 12 % as females (Table 4). The assumption that all striped bass identified as sex unknown ripen and spawn as female fish would have been inaccurate in 1999. Furthermore, it is not known if all striped bass identified as sex unknown ripen and spawn. In 1999, striped bass identified as not spent and sex unknown were captured throughout, and at the end of the gaspereau season (June 18), presumably after spawning was complete for the year.

Forklength distributions were similar between adult fish tagged in the Napan River, and the NW Miramichi River (both from trapnets in the gaspereau fishery and at Hackett's Beach) (Figure 3), similar to other assessments (Bradford et al. 2001).

Biological Characteristics in 2000

Similarly to 1999, a high percentage (32%) of striped bass sampled in the NW Miramichi was identified as sex unknown (Table 3). From striped bass with positively identified sex, 64% were male, and 4% female (Table 3). Of the 80 NW Miramichi striped bass tagged as sex unknown, 16 of these fish were recaptured. Only one striped bass ripened enough to be identified as male, the others remained unknown (Table 4).

The average forklength of adult striped bass sampled during the 2000 gaspereau season was 48.8 cm (Figure 4).

ESTIMATION OF STOCK PARAMETERS

In 1999

Three pools of tags (Napan, NW Miramichi, and Hackett's Beach) were tracked individually through the NW Miramichi gaspereau season. A Bayesian estimator, as described by Gazey and Staley (1986), was used to calculate population size separately for each tag pool. Both a single census for the entire season and a sequential census for each day of fishing was calculated for each tag pool. The most probable population size given R recaptures out of M marks placed in a sample catch of C was calculated over a range of possible population sizes. Tag loss was assumed to be negligible over the short period (two months) of the experiment. The reporting rate was assumed to be 100% (daily contact with fishermen in the NW Miramichi).

The criteria used to determine the day for termination of the mark-recapture experiment was similar to previous assessments (Bradford and Chaput 1997, 1998; Bradford et al. 2001), and based on (1) a decline in the number of recaptures over time, (2) the direct observation of the reproductive state of the adults over time, and (3) the decline in CPUE of adult bycatch over time. Recapture profiles of all three pools of tagged fish behaved similarly during the gaspereau season, dropping dramatically after June 8 (Figure 5). The decline in recapture rates after June 8 suggests that the majority of striped bass left the river to start their summer coastal migrations. Spent female striped bass were not observed beyond June 2 (Figure 6), however mature female striped bass were observed on June 8 and June 14. Qualitative interpretations of direct observations of spent adults indicated that a major spawning event occurred between June 1-2, 1999. Catch per unit of effort of adult striped bass in the gaspereau fishery declined after June 8 (Figure 7). June 8 was used as the termination date for 1999.

In 2000

Similar to estimates in 1999, a Bayesian estimator was used to calculate the population size for the 2000 spawning season. Both a single census for the entire season and a sequential census for each day of fishing were calculated for the NW Miramichi tag pool.

Similar termination date criteria for the recapture phase of the experiment was used in 2000 as was in 1999. The recapture rate of tagged striped bass remained fairly constant over the duration of the mark-recapture experiment (Figure 5). Both ripe and spent female striped bass were last observed on June 16 (Figure 6), and suggests that spawning in 2000 was more protracted than in recent years. Qualitative interpretations of direct observations of spent adults indicated that a major spawning event occurred between June 1-2, 2000. Adult CPUE in the gaspereau fishery declined after June 2 but remained constant until the end of the gaspereau season (Figure 7). June 21, the last day of gaspereau season, was used as the termination date for 2000.

Index of Adult Abundance - CPUE

Because a sampler was present at as many trapnets as possible during each day any trapnets were fished, precise calculations of catches per unit of effort (CPUE) were possible over the entire NW Miramichi gaspereau season in 1999 and 2000. These data represent year-

to-year changes in the average catch of striped bass in the NW Miramichi gaspereau fishery, and are not necessarily a precise measure of spawner abundance.

An analysis of variance (ANOVA) model was used to analyse CPUE of adult striped bass in the NW Miramichi gaspereau fishery for years 1993 to 2000 (Gavaris 1980). Catches of striped bass over the entire gaspereau season for each year were used in the analysis. Year was used as a category variable and date of sampling as a continuous variable (estimating decline in CPUE over the season). Striped bass catch data were fitted to two models using (SAS) GLM procedures. The first model did not have an interaction term between year and date (assumes a constant slope for all years but different intercept for year), while the second model used an interaction term between year and date of sampling (assumes a slope which depends on year and an intercept which can vary with year).

Model 1: Ln(CPUE + 0.1) = year date

Model 2: Ln(CPUE + 0.1) = year date year * date

The predicted values of year represent the annual means adjusted for the decline over the season. The CPUE data (catch/trap/day) were log transformed before analysis and adjusted upward by 0.1 before log transformation. Arithmetic and geometric means were also calculated for years 1993-2000 as additional indicators of change in abundance among years.

ASSESSMENT RESULTS

Spawner Abundance Estimate In 1999

Sequential Bayesian population estimates of all three pools of tagged fish indicated that the 1999 spawning run on the NW Miramichi was between 3,000 and 5,000 fish. Sequential estimates of population size were highest at the beginning of the season (May 21) but decreased rapidly as catches and recaptures increased by May 27 (Table 5). Each group of tagged fish produced a sequential estimate on June 8 similar to the single census estimate (end of season) for their respective tag pool (Table 5). The sequential census estimate of 3940 spawners on June 8, 1999, from the Napan pool of tags, was brought forward as the population size in 1999 (Figure 8).

Spawner Abundance Estimate In 2000

Sequential Bayesian estimates of population size indicated that the 2000 spawning run on the NW Miramichi consisted of approximately 3,900 fish. Sequential estimates of population size settled at about 4,000 spawners after May 31, and remained there until the end of the gaspereau season (Table 5). The sequential estimate of June 21 approximated that of the single census estimate for the entire season (Table 5). The sequential census estimate of 3,900 spawners on June 21, 2000 was brought forward as the population size in 2000 (Figure 9).

Adult CPUE Trends

The 1999 average catch per unit of effort (catch/trap/day) of striped bass varied between a high of 63 on the first day of fishing (May 21) to 0 on the last day of the gaspereau season (June 18). Similar to most years, striped bass catches declined progressively throughout the gaspereau season (Figure 7). Mean catches of striped bass remained relatively constant after June 8, 1999. In 2000, CPUE of striped bass ranged from 58 on the first day of fishing (May 25) to 3 on the last day of fishing (June 21), and remained constant after May 30 (Figure 7).

The generalized linear model indicated that CPUE among traps within a year and among years is highly variable (Table 6). The model with the year and date interaction term explained only 32% of the total variance. CPUE in 1993, and from 1996 to 2000 was similar and significantly less ($P<0.01$) than CPUE in 1994 and 1995 (Figure 10). Although the linear relationship between mean catch/trap/day and population size is weak ($r^2 = 0.39$), mean catches have always been below 10 when spawners have been estimated to be less than 10,000 (Figure 11).

Year-Class Composition and Sex Ratio

The 1996 year-class was the most abundant age group of the spawning run to the NW Miramichi in 1999 (Figure 12). This was corroborated by the fact that the 1996 year-class had the highest CPUE (median of 452 0+ striped bass) of all year-classes sampled in the commercial smelt fishery since 1993 (Bradford et al. 2001). The majority of the 1996 year-class was male recruiting to the spawning population for the first time. The 1995 year-class was the next most numerous age group but had a higher proportion of fish identified as sex unknown. Year-classes older than 1994 were virtually absent in the 1999 gaspereau fishery.

Although the 2000 spawning population was dominated by the 1996 and 1997 year-classes, abundance of these fish was comparatively low in 2000 to other years (Figure 12). The contribution of females from the 1996 year-class was lower than expected in 2000 and abundance of male striped bass from the 1997 year-class recruiting for the first time was poor. Given the poor representation of the 1997 year-class in the smelt fishery (median CPUE of 10 0+ striped bass) (Bradford et al. 2001), it is likely that female recruitment will also be low in 2001. Although the 1998 year-class was somewhat represented in the 2000 gaspereau fishery, predictions for this year-class are difficult given the possible wide distribution of two year old striped bass in other southern Gulf estuaries (Robinson 2000). The 1999 year-class appears to be large bodied and have had good survival up until the 2000 sampling of the gaspereau fishery (Figure 4). It is expected that no substantial recruitment will occur before the large bodied 1999 year-class returns to spawn in 2002 (males), and 2003 (females).

Beach Seine Survey 2000

Catches of underyearling striped bass varied from 0 to 491 (mean 19) per beach seine sweep in 2000 (Table 7). The largest catch was at Indian Island in the Richibucto River (Table 7). Qualitative evidence suggests that abundances of YOY were less in 2000 than in 1999 when single beach seine sweeps often produced > 1000 YOY at different locations throughout the summer (personal observation). Higher beach seine CPUEs in 1999 suggests that spawner success may have been greater in 1999 than in 2000. These interpretations were not confirmed with 0+ CPUE data from the smelt fishery of the Miramichi Estuary. Successive years of beach

seine data are needed before this method can be used as an index of spawner success in the southern Gulf of St. Lawrence.

Mean forklengths of 0+ striped bass increased throughout the summer (Figure 13) with a maximum value of 110 mm recorded from fish collected in the Miramichi Estuary on September 14 (Table 7). Although pre-winter size of Miramichi YOY is highly variable among years, forklengths observed in September and October 2000 were similar to most other years (Bradford et al. 2001). Growth of YOY may have been normal or limited in 2000 since summer air and water temperatures were slightly below the average for the Miramichi River (Caissie 2001 in prep).

Sources of Uncertainty

The number of tags that were removed in 1999 by commercial gaspereau fishermen in the areas of Loggieville and Chatham before the bass reached the spawning grounds in Newcastle is unknown. Only one fisherman from both Loggieville and Chatham returned tags with catch information in 1999, none were returned in 2000. Tags returned by fishermen located in areas other than the NW Miramichi have been extremely low in the past, and are assumed to be negligible.

The arrival time of striped bass on the spawning grounds was unknown in 1999 and 2000. Catches of striped bass in both years were largest during the first fishing event of the year (Figure 7). These data suggest that striped bass were in the area before effort increased in the gaspereau fishery.

ECOLOGICAL CONSIDERATIONS

The majority of striped bass captured in the Napan River in 1999, one to two weeks prior to the spawning season, were not ripe enough to expel sexual fluids so that their sex could be positively identified. The assumption that all fish identified as sex unknown ripen, and/or spawn, as female striped bass cannot be made for 1999 or 2000. Sex ratios of fish with positively identified sex need to be considered as minimum values, and as such, will affect the maximum amount of the conservation requirement that could have been achieved in 1999 and 2000. Even with best case scenarios, the provisional conservation requirement could not have been met in either year.

Pre-winter size of YOY in 1999

Young-of-the-year were sampled on two occasions in 1999 (once in September and November) from bagnets of the commercial smelt fishery adjacent to the Tabusintac River. Pre-winter mean length of YOY striped bass was 15.3 cm (range of 12.0-19.1 cm) (Figure 14), substantially larger than any other 0+ year-class sampled in the commercial smelt fishery since 1993. Better growth of 0+ striped bass during the summer of 1999 was probably related to above average air and water temperatures for the Miramichi River (Caissie 2000). Numerous studies have recorded better striped bass growth when water temperatures are elevated (Peterson et al. 1996).

Juvenile Mortality

The NW Miramichi striped bass population may be constrained by size-dependent winter mortality of underyearling fish (Chaput and Robichaud 1995; Bernier 1996; Bradford and Chaput 1997; Robichaud-LeBlanc et al 1998). The minimum body size needed for 0+ Miramichi striped bass to survive their first winter has been back calculated to be about 10 cm (Bernier 1996). Hurst and Conover (1998) also have demonstrated size-dependant mortality for striped bass in the Hudson River during severe winter conditions. The variability among years in the average pre-winter lengths of 0+ Miramichi striped bass combined with differences in spawner success will affect the recruitment to the spawning population. In this regard, it may be important that the 1999 year class is large bodied. The important 1991 year class, a cohort of low numerical abundance at age 0+, was also large bodied entering the winter (modal fork length = 13 cm) (Bradford et al. 2001).

Older age classes of striped bass may also be vulnerable during the winter when they reside under the ice, in the brackish waters of the upper parts of estuaries, without feeding (Bradford et al. 1997; Bradford et al. 2001). High freshwater discharge events as well as effluent discharges from municipal and industrial activities have also been reported to adversely affect striped bass habitat (Robichaud-LeBlanc et al. 2000).

FORECASTS/PROSPECTS

The 1990 categorization of southern Gulf of St. Lawrence striped bass as reduced or declining (Chaput and Randall 1990) remains appropriate. There are no indications that abundance of female striped bass of the 1997 year-class or the male component of the 1998 year-class will be abundant. Recruitment of 3-year-old males (1997 year-class) in 2000 was poor which precludes the same for the 4-year-old females of the same year-class recruiting in 2001. The conservation requirement is not likely to be met in 2001. Evidence suggests that the 1999 year-class are large bodied which could lead to better recruitment in 2002-03.

MANAGEMENT CONSIDERATIONS

Southern Gulf of St. Lawrence striped bass remain at low abundance. Spawner abundance has declined since the closure of directed fisheries in 1996 and remained low in 1999 and 2000 at just under 4000 fish.

Southern Gulf of St. Lawrence striped bass did not achieve the spawning requirement in 1999 or 2000. Southern Gulf striped bass have not met the conservation requirement since 1996. There are no indications that recruitment will rebuild this population above the conservation requirement before 2003. Existing spawners require the maximum possible degree of protection through measures that would include:

1. deterrence of poaching

and, since there is no longer a harvestable surplus of fish:

2. reduce or eliminate interception of striped bass in gillnet based First Nation fisheries for other species of food fish

3. communicate to all parties (First Nations, commercial fishers, recreational fisheries, provincial governments, watershed groups etc.) the need for improved collaboration in order to realize effective conservation.

RESEARCH RECOMMENDATIONS

The adult component of the striped bass program hinges on access to the fish through commercial gaspereau traps of the NW Miramichi River. Gaspereau season openings and effort are highly variable among years and often creates the problem of not having sufficient recapture facilities working as striped bass are first arriving. Commercial fishermen in the NW Miramichi could be contracted to operate trapnet(s) before the beginning of gaspereau season to ensure that striped bass arriving early in the season are sampled adequately.

If mark-recapture experiments are to be continued for the NW Miramichi population estimate, a new method of marking striped bass needs to be evaluated. Qualitative data suggests that puncture wounds administered by the needle from the tagging gun are susceptible to lymphocystis. The proportion of lymphocystis-infected striped bass from all fish sampled in 1999 and 2000 was 2% (minimum since sampling of NW Miramichi did not include checking for lymphocystis) and 5% respectively. Eight of 33 striped bass tagged in 1999 were infected with lymphocystis by the time they were recaptured on the spawning grounds in 2000.

Resume sampling of the open-water commercial smelt fishery of the Miramichi estuary and extend sampling to Richibucto and surrounding estuaries. Young-of-the-year are abundant in other estuaries along the coast of the southern Gulf of St. Lawrence and their complete distribution needs to be verified.

Initiate YOY sampling in summer and fall with the American eel fishery in the Miramichi Estuary and along the coast of the southern Gulf of St. Lawrence.

Continue and develop a more rigorous beach seine survey of the Miramichi and surrounding estuaries. Beach seine catch data over years may provide an index of abundance of YOY.

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Table 1. First Nations' harvest agreement levels and reported harvests of striped bass for 1999 and 2000. (na = not available).

First Nation	Location of fishery	Allocation	Harvests 1999	Harvests 2000
Burnt Church[1]	Tabusintac River and Miramichi Bay	40[2]	na	na
Eel Ground	Northwest Miramichi River	150[3]	na	na
Red Bank	Northwest Miramichi River	100[3]	na	na
Indian Island	Richibucto River	500[3]	na	na
Big Cove[1]	Richibucto River		na	na
Buctouche	Buctouche River	172[3]	na	na
Millbrook	River Phillip, NS		na	na

[1] no agreement since 1996
[2] 1996 agreement level
[3] 1998 agreement level

Table 2. Date, location, and number of tags applied in 1999 and 2000. Tags recaptured from a previous year were from fish originally tagged in the Napan or Northwest Miramichi Rivers.

Date	Tagging location	Tags applied in	
		Current year	Previous year(s)
1999			
11-May	Napan	75	3
13-May	Napan	35	2
15-May	Napan	17	0
17-May	Napan	189	1
19-May	Napan	204	1
21-May	Napan	67	1
Total	Napan	**587**	**8**
21-May	Northwest Miramichi	260	2
27-May	Northwest Miramichi	0	3
29-May	Northwest Miramichi	0	2
2-Jun	Northwest Miramichi	0	1
3-Jun	Northwest Miramichi	0	1
5-Jun	Northwest Miramichi	0	2
6-Jun	Northwest Miramichi	0	1
15-Jun	Northwest Miramichi	0	2
Total	Northwest Miramichi	**260**	**14**
6-May	Hackett's Beach	1	0
10-May	Hackett's Beach	1	0
11-May	Hackett's Beach	1	0
20-May	Hackett's Beach	30	0
21-May	Hackett's Beach	9	0
22-May	Hackett's Beach	4	0
23-May	Hackett's Beach	9	0
24-May	Hackett's Beach	7	1
Total	Hackett's Beach	**62**	**1**
2000			
25-May	Northwest Miramichi	86	24
26-May	Northwest Miramichi	21	1
27-May	Northwest Miramichi	36	1
30-May	Northwest Miramichi	45	1
1-Jun	Northwest Miramichi	0	3
2-Jun	Northwest Miramichi	0	4
3-Jun	Northwest Miramichi	0	1
5-Jun	Northwest Miramichi	0	2
6-Jun	Northwest Miramichi	0	1
8-Jun	Northwest Miramichi	0	1
11-Jun	Northwest Miramichi	0	1
13-Jun	Northwest Miramichi	0	1
16-Jun	Northwest Miramichi	0	2
17-Jun	Northwest Miramichi	0	1
19-Jun	Northwest Miramichi	0	5
Total	Northwest Miramichi	**188**	**49**

Table 3. Sex ratios of all striped bass sampled in 1999 and 2000.

Sample	Total sampled				Proportion of sample		
	Male	Female	Unknown	Total	Male	Female	Unknown
1999							
Napan River	340	1	248	589	58%	0%	42%
Northwest Miramichi	963	47	297	1307	74%	4%	23%
Hackett's Beach	118	6	30	154	77%	4%	19%
All	1421	54	575	2050	69%	3%	28%
2000							
Northwest Miramichi	695	48	347	1090	64%	4%	32%

Table 4. Sex ratios of striped bass at time of tagging and change of sex ratios at time of recapture for the proportion of striped bass tagged and released as sex unknown in 1999 and 2000. Percentages in brackets.

Sample	Tagged as			Number of recaptures	Recaptures remained			Recaptures ripened to	
	Male	Female	Unknown		Male	Female	Unknown	Male	Female
1999									
Napan River	340 (58)	1 (0)	248 (42)	173	112 (90)	0 (0)	13 (10)	42 (88)	6 (12)
Northwest Miramichi	188 (69)	22 (8)	64 (23)	62	50 (82)	2 (3)	9 (15)	0 (0)	1 (100)
Hackett's Beach	44 (70)	6 (9)	13 (21)	17	14 (82)	0 (0)	3 (18)	0 (0)	0 (0)
2000									
Northwest Miramichi	151 (64)	5 (2)	80 (34)	41	24 (60)	1 (2)	15 (38)	1 (100)	0 (0)

Table 5. Summary of single (for season) and sequential (for days) census spawner population size estimates for 1999 and 2000. M = marks, C = catch, R = recaptures, and C.I. = confidence interval.

		Mark recapture data			Total spawners		C. I.	
Estimation method	Recapture sample	M	C	R	Mode	Median	0.025	0.975
1999								
Bayesian (Sing. Census)	Napan	447	1607	211	3390	3390	3000	3870
Bayesian (Mul. Census)	Napan May 21, 1999	527	311	36	4570	4640	3450	6460
Bayesian (Mul. Census)	Napan May 27, 1999	568	493	70	4290	4290	3590	5130
Bayesian (Mul. Census)	Napan June 1, 1999	532	75	7	4290	4290	3730	4990
Bayesian (Mul. Census)	Napan June 8, 1999	474	34	3	3940	3870	3450	4430
Bayesian (Mul. Census)	Napan June 17, 1999	447	5	0	4080	4080	3590	4640
Bayesian (Sing. Census)	Northwest Miramichi	225	1607	67	5400	5450	4350	7000
Bayesian (Mul. Census)	NWM May 25, 1999	262	40	1	10450	9850	3250	15400
Bayesian (Mul. Census)	NWM May 27, 1999	258	493	24	5500	5650	3850	8650
Bayesian (Mul. Census)	NWM June 1, 1999	248	75	0	5050	5200	3850	7150
Bayesian (Mul. Census)	NWM June 8, 1999	232	34	1	4750	4600	3700	5950
Bayesian (Mul. Census)	NWM June 17, 1999	225	5	0	4900	4900	3850	6250
Bayesian (Sing. Census)	Hackett's Beach	51	1607	17	4800	5200	3250	8900
Bayesian (Mul. Census)	HB May 21, 1999	33	311	1	10300	9850	3100	15400
Bayesian (Mul. Census)	HB May 27, 1999	59	493	6	4150	4600	2500	9850
Bayesian (Mul. Census)	HB June 1, 1999	57	75	1	3850	4000	2500	7150
Bayesian (Mul. Census)	HB June 8, 1999	53	34	0	4750	5050	3100	8650
Bayesian (Mul. Census)	HB June 17, 1999	51	5	0	5050	5350	3250	9100
2000								
Bayesian (Sing. Census)	Northwest Miramichi	236	1135	45	5950	6100	4600	8300
Bayesian (Mul. Census)	NWM May 31, 2000	215	16	3	3900	4650	2100	12000
Bayesian (Mul. Census)	NWM June 1, 2000	215	65	5	3300	3600	2100	7500
Bayesian (Mul. Census)	NWM June 5, 2000	222	50	3	3450	3450	2250	5700
Bayesian (Mul. Census)	NWM June 10, 2000	226	2	0	3750	3900	2700	5700
Bayesian (Mul. Census)	NWM June 15, 2000	228	25	1	3900	3900	2850	5550
Bayesian (Mul. Census)	NWM June 21, 2000	236	27	4	3900	3900	2850	5250

Table 6. Annual mean CPUE (catch/trap/day) of striped bass in the NW Miramichi gaspereau fishery for years 1993 to 2000. Means and coefficients of variation (CV) were from generalized linear models (ANOVA) with and without a year by date interaction term. Unadjusted arithmetic and geometric means are also included.

	Without interaction		With interaction		Unadjusted arithmetic		Geometric	
Year	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1993	1.7	38%	1.1	163%	4.0	154%	1.3	87%
1994	30.9	6%	30.9	5%	65.8	9%	30.5	6%
1995	12.0	7%	12.0	7%	35.7	15%	12.4	7%
1996	6.4	9%	5.9	9%	9.0	55%	5.5	10%
1997	3.0	16%	3.3	16%	4.9	110%	2.4	22%
1998	3.5	12%	3.9	12%	10.4	44%	5.2	10%
1999	2.3	14%	2.0	17%	7.3	49%	2.7	13%
2000	4.7	9%	4.4	9%	6.6	63%	3.8	11%

Table 7. Date, locations and average biological characteristics of YOY striped bass collected during the beach seine survey in 2000.

				Mean	
Date	River	Location	Catch	FL (mm)	Weight (g)
2-Aug	Northwest Mir.	Hackett's Beach	13	44.8	1.11
2-Aug	Miramichi	Kerr's Point	28	52.8	1.97
2-Aug	Miramichi	Gordon's Wharf	148	47.9	1.49
3-Aug	Gulf Coast	Neguac Municipal Pk.	13	52.5	1.88
3-Aug	Tabusintac	Above Rt. 11 bridge	2	61.5	3.00
3-Aug	Tabusintac	McLean Rd. Site 1	11	66.1	3.85
4-Aug	Richibucto	Indian Island	6	61.5	2.95
4-Aug	Richibucto	Jardine Park	3	54.3	2.07
8-Aug	Gulf Coast	Bayshore Road	1	57.0	1.90
8-Aug	Tracadie	Pont LaFrance	0		
15-Aug	Northwest Mir.	Cassilis (opposite)	4	48.8	1.43
15-Aug	Northwest Mir.	Hackett's Beach	31	62.4	3.14
15-Aug	Miramichi	Tyrell's Point	5	88.4	8.52
15-Aug	Miramichi	Gordon's Wharf	27	74.7	5.69
18-Aug	Northwest Mir.	Hackett's Beach	0		
18-Aug	Miramichi	Kerr's Point	12	78.9	6.83
18-Aug	Miramichi	East Point	65	65.0	4.19
18-Aug	Miramichi	Gordon's Wharf	0		
22-Aug	Northwest Mir.	Hackett's Beach	3	52.3	1.80
23-Aug	Gulf Coast	Neguac Municipal Pk.	1	73.0	4.40
23-Aug	Tabusintac	McLean Rd. Site 1	13	90.4	9.50
23-Aug	Tabusintac	McLean Rd. Site 2	0		
23-Aug	Tabusintac	Gaythorne Rd. Site 1	6	95.3	10.92
30-Aug	Richibucto	Indian Island	491	91.3	10.60
30-Aug	Richibucto	Jardine Park	6	78.7	5.95
7-Sep	Northwest Mir.	Cassilis (opposite)	0		
7-Sep	Northwest Mir.	Hackett's Beach	4	79.3	6.80
7-Sep	Northwest Mir.	McKay Cove	5	99.6	13.24
13-Sep	Miramichi	East Point	0		
13-Sep	Miramichi	Gordon's Wharf	0		
14-Sep	Miramichi	Middle Island	6	110.3	17.88
14-Sep	Miramichi	East Point	0		
14-Sep	Miramichi	Gordon's Wharf	2	102.5	14.05
21-Sep	Richibucto	Indian Island	0		
21-Sep	Richibucto	Jardine Park	4	79.8	5.24
21-Sep	Gulf Coast	St. Edouard de Kent	0		
21-Sep	Buctouche	Below Rt. 11 bridge	0		
21-Sep	Little Buctouche	Below Rt. 134 bridge	0		
21-Sep	Cocagne	Below Rt.134 bridge	0		
21-Sep	Shediac	Below Rt 134 bridge	0		
5-Oct	Miramichi	Gordon's Wharf	0		
5-Oct	Gulf Coast	Neguac Municipal Pk.	0		
5-Oct	Tabusintac	McLean Rd. Site 1	0		
5-Oct	Tabusintac	Gaythorne Rd. Site 1	0		
6-Oct	Northwest Mir.	Hackett's Beach	2	104.5	14.64
6-Oct	Miramichi	Middle Island	0		
6-Oct	Miramichi	East Point	0		
6-Oct	Richibucto	Indian Island	0		
6-Oct	Richibucto	Jardine Park	0		

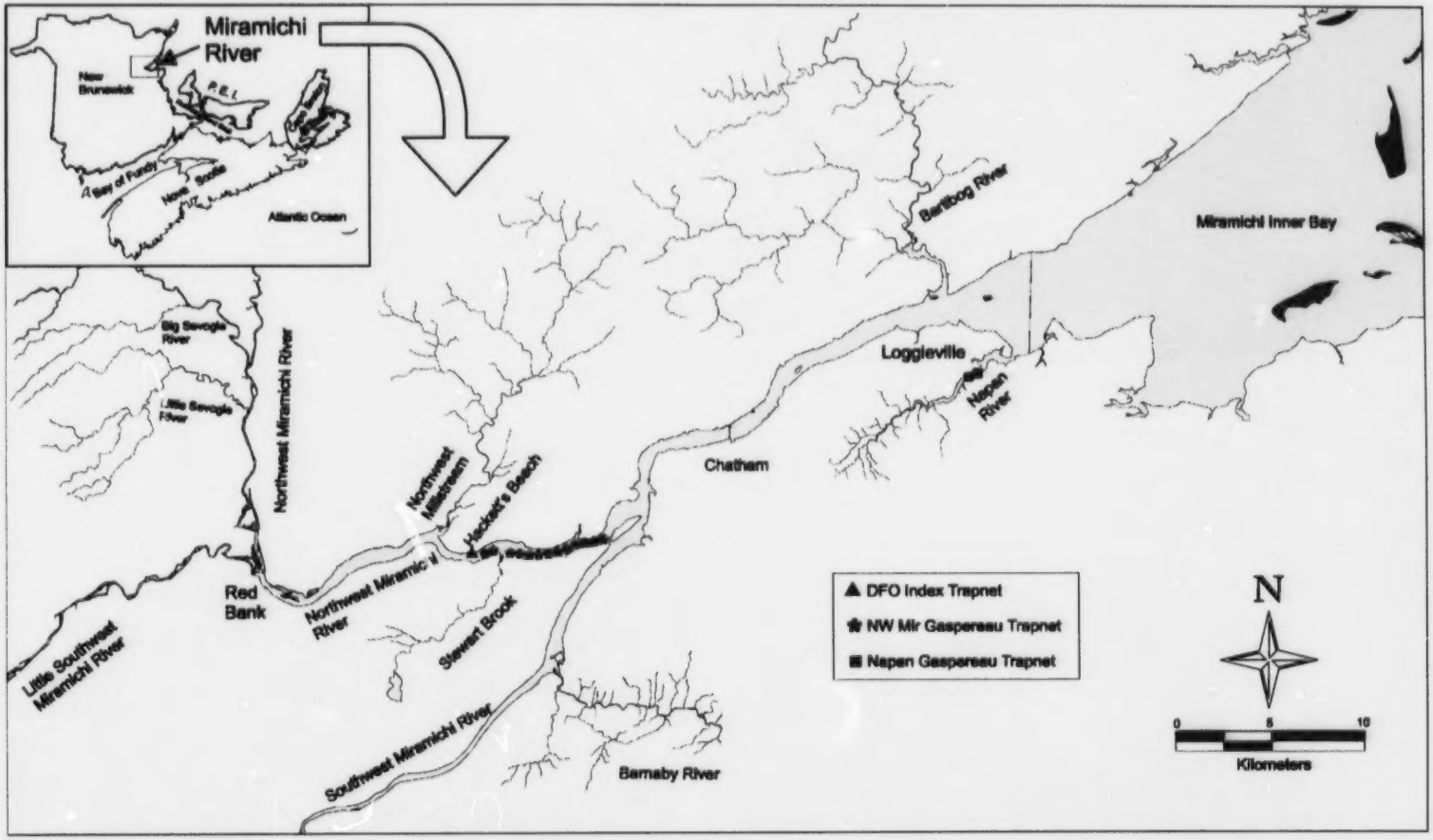

Figure 1. Location of DFO index trapnet and commercial gaspereau trapnets in the Northwest Miramichi River and gaspereau trapnets used to mark striped bass in the Napan River in 1999 and 2000.

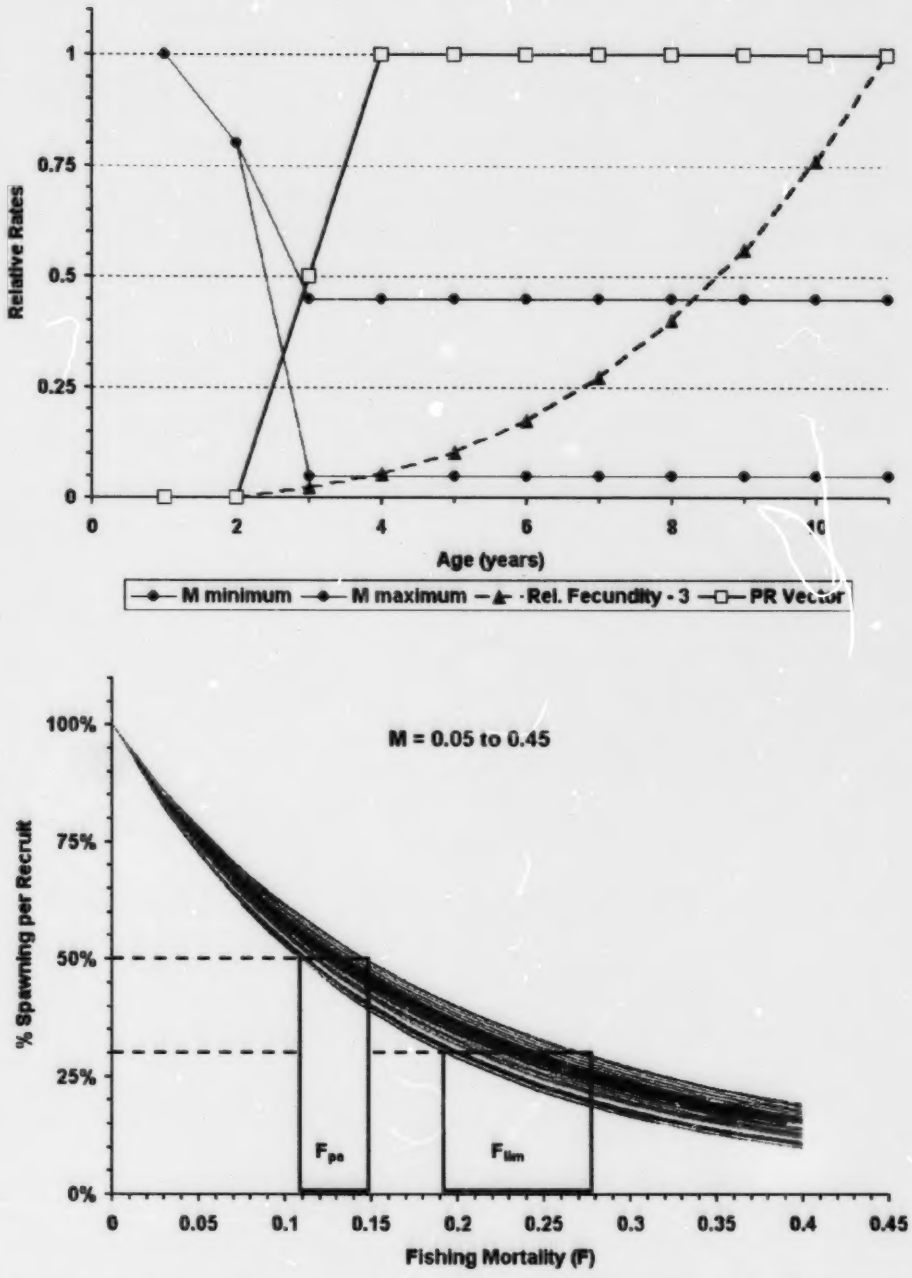

Figure 2. Input parameters (upper) for the SPR analysis and the %SPR results (lower) for assumed M of 0.05 to 0.45 for striped bass.

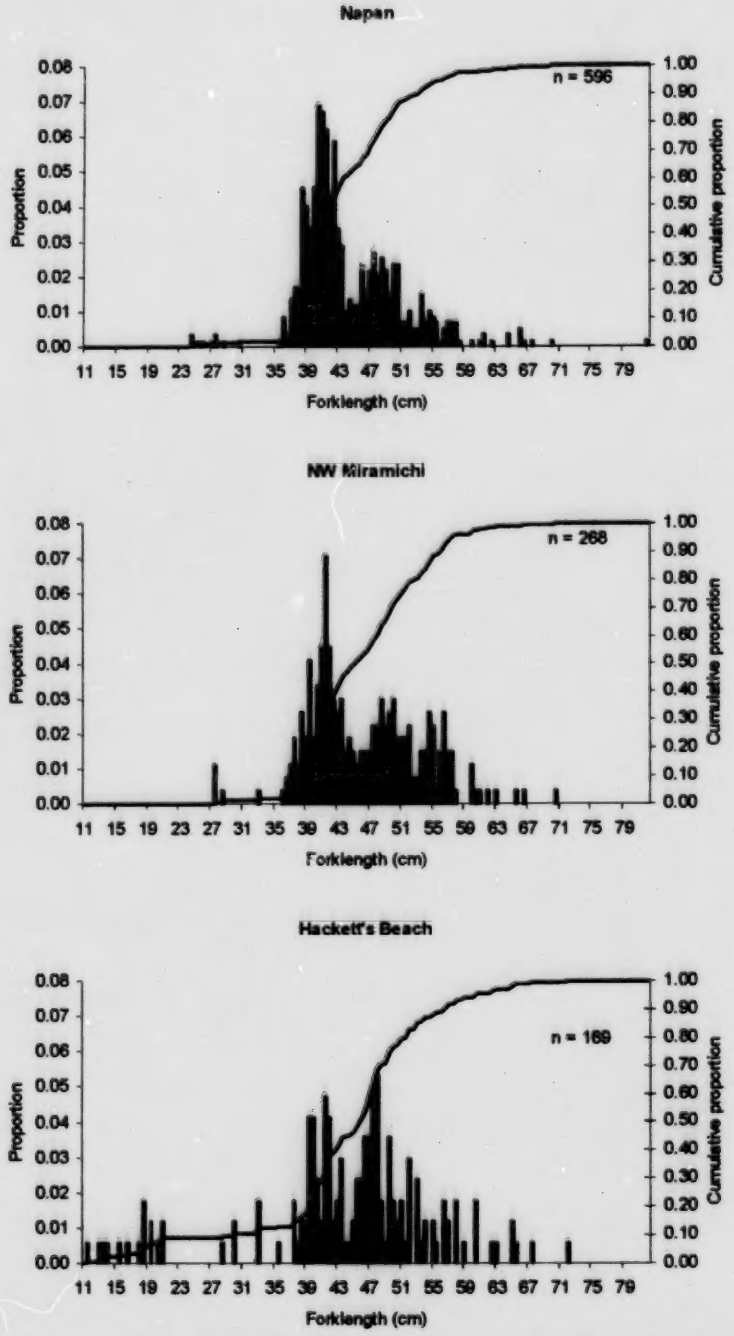

Figure 3. Forklength distributions of fish sampled in the Napan River (upper), NW Miramichi (during the single tagging event only) (middle), and the NW Miramichi at Hackett's Beach (lower), 1999.

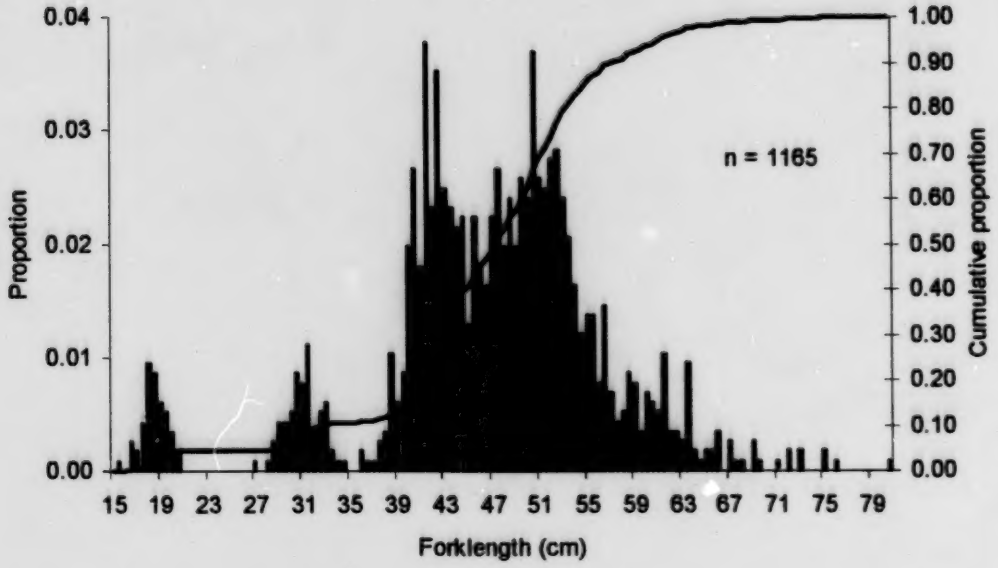

Figure 4. Forkiength distribution of striped bass sampled throughout the gaspereau fishery of the Northwest Miramichi River, 2000.

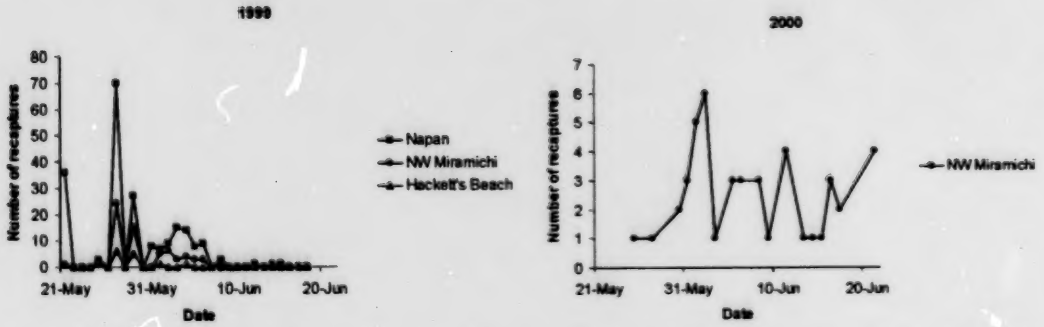

Figure 5. Observed striped bass recaptures during the gaspereau season of the Northwest Miramichi River in 1999 (left) and 2000 (right). Recaptures in 1999 belonged to either the Napan, Northwest, or Hackett's Beach tag pool.

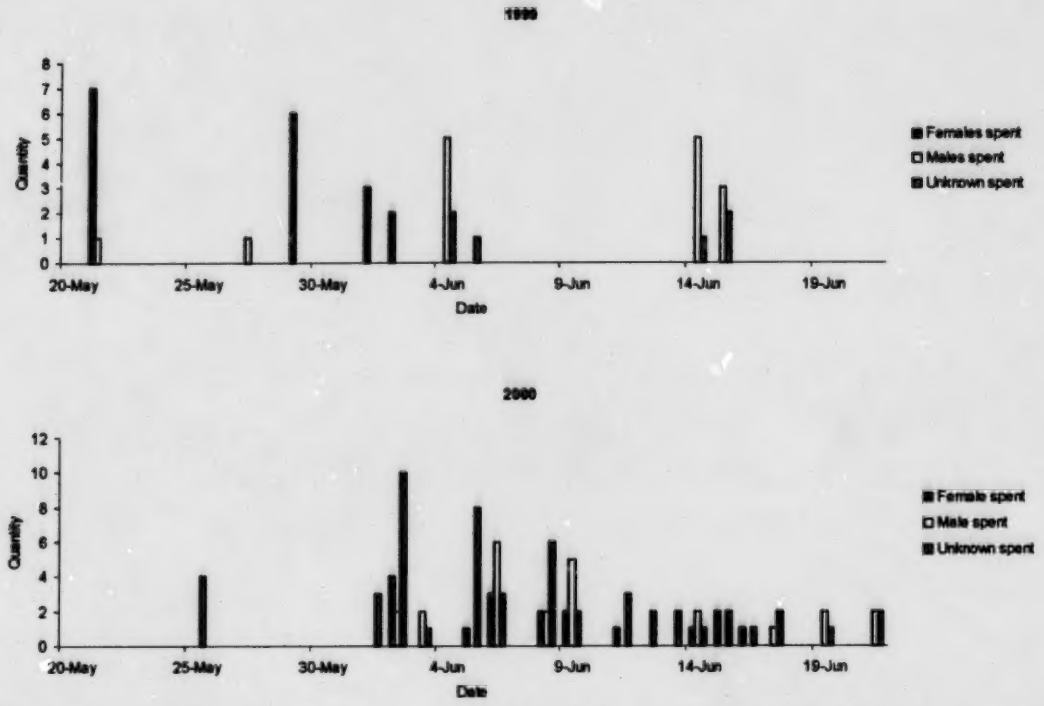

Figure 6. Spent striped bass observed during the 1999 (upper panel) and 2000 (lower panel) gaspereau seasons of the NW Miramichi River.

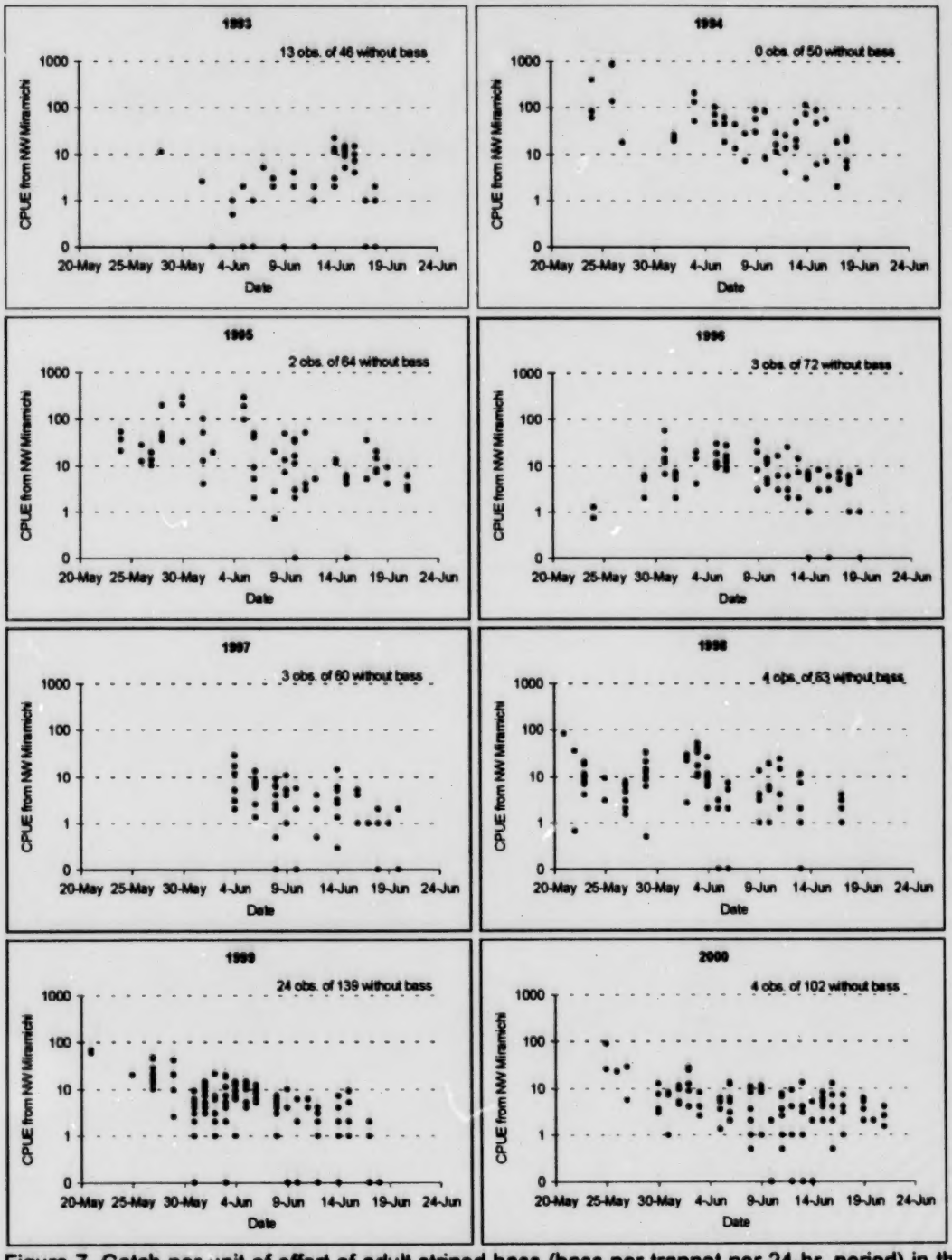

Figure 7. Catch per unit of effort of adult striped bass (bass per trapnet per 24-hr. period) in the commercial gaspereau fishery of the NW Miramichi River for years 1993 to 2000. Individual points may represent several observations.

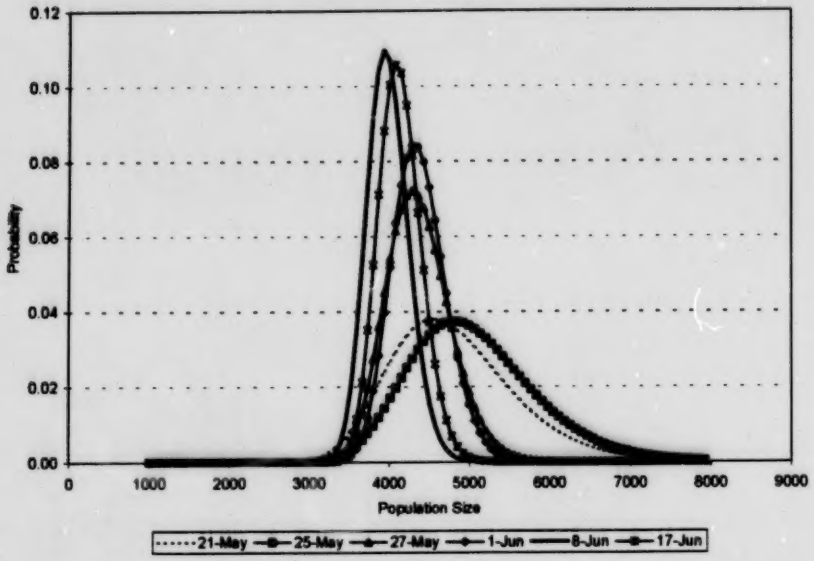

Figure 8. Sequential Bayesian estimates of spawner abundance based on tags applied in the Napan River and recaptured on the NW Miramichi in 1999. Bolded line (June 8) represents population estimate (3940 spawners) brought forward for the assessment.

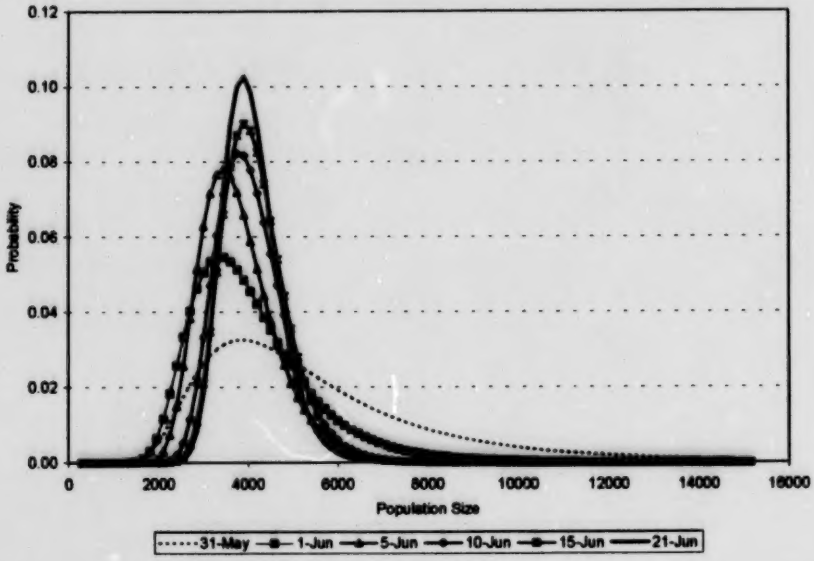

Figure 9. Sequential Bayesian estimates of spawner abundance for 2000. Bolded line (June 21) represents population estimate (3900 spawners) brought forward for the assessment.

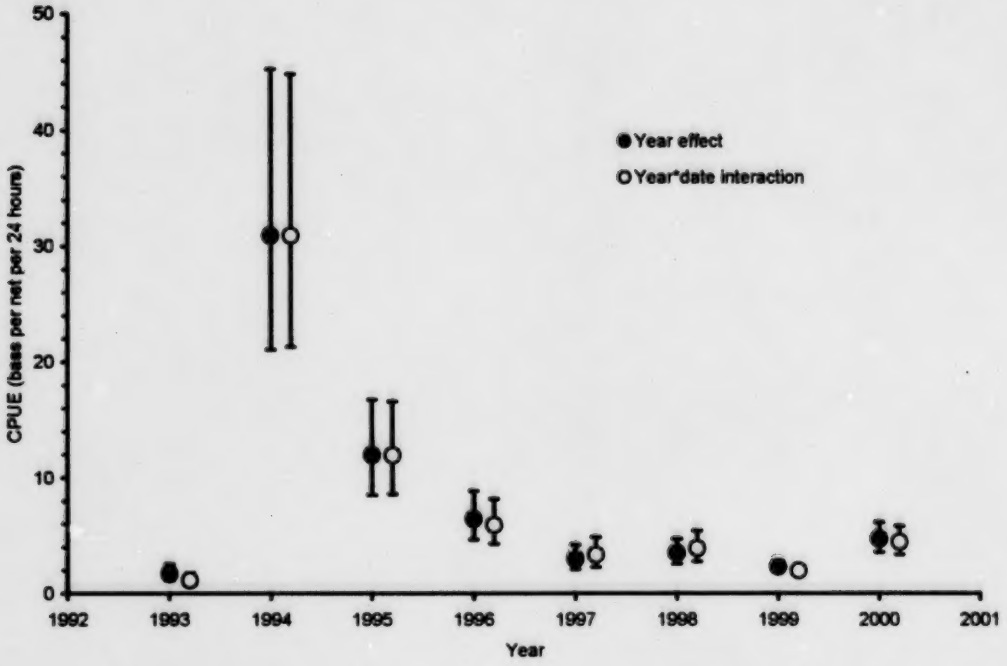

Figure 10. Relative CPUE (catch per net per 24 hours) of adult striped bass on the spawning grounds of the NW Miramichi River for the entire gaspereau season, 1993 to 2000.

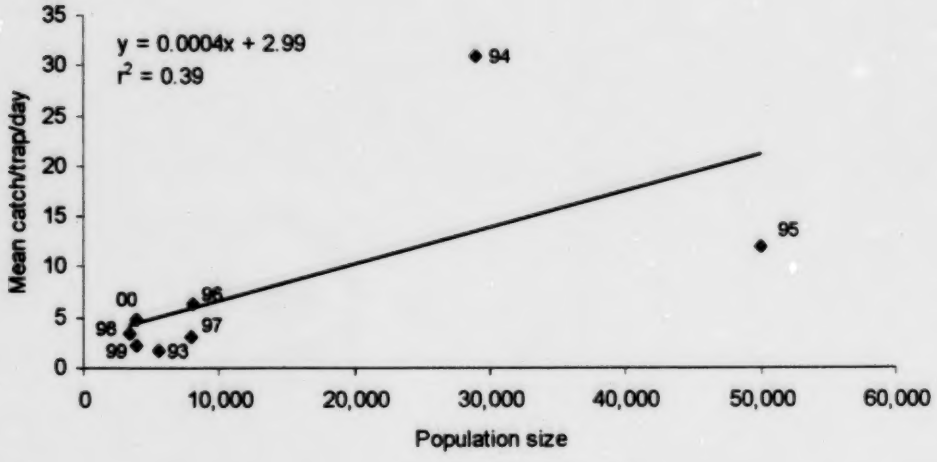

Figure 11. Relationship between mean catch per trap per day (GLM model) and estimated abundance of spawners for years 1993 to 2000.

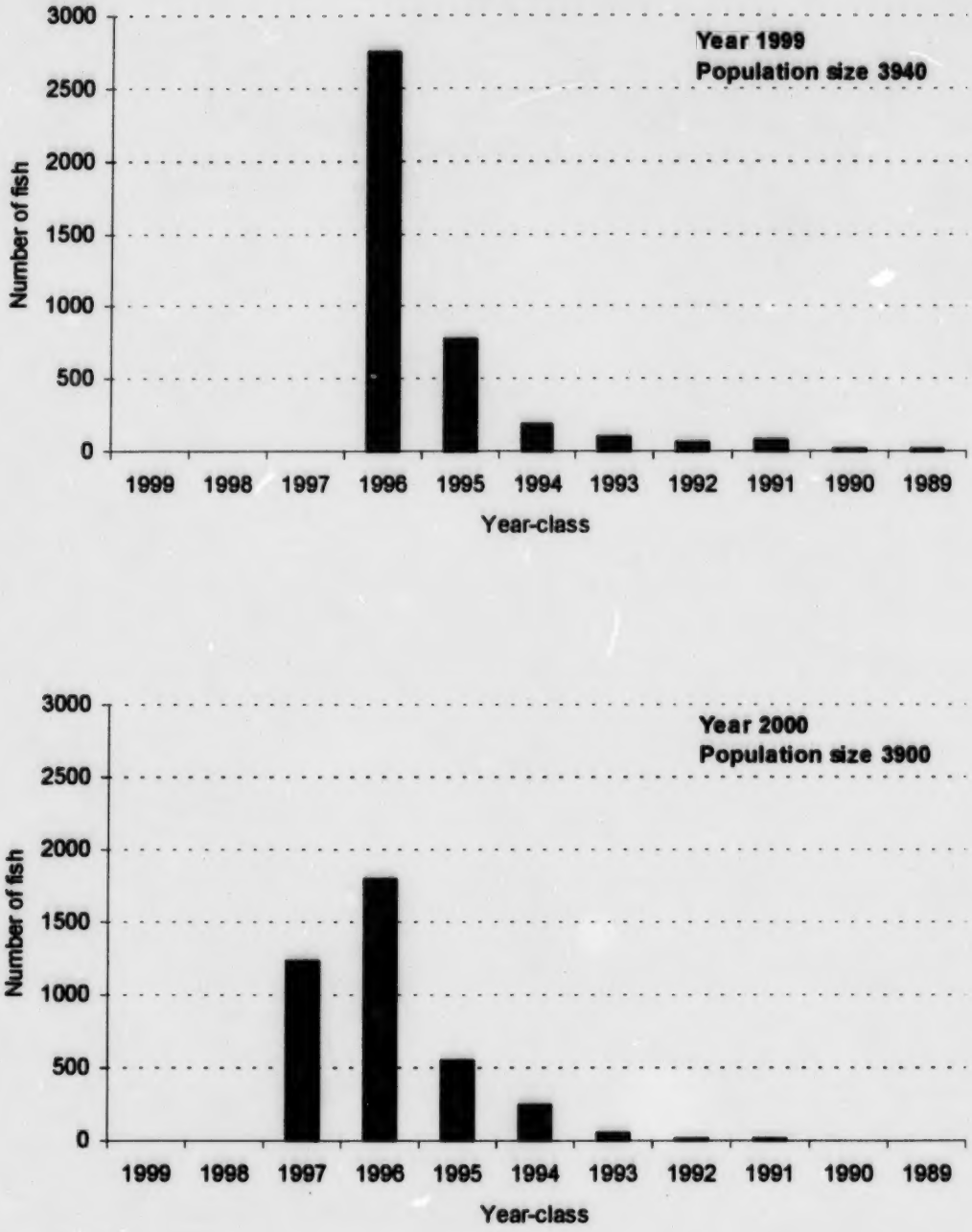

Figure 12. Year class composition of the spawning run in 1999 (upper panel) and 2000 (lower panel). Year-class composition in 1999 is based on the forklength distribution of Napan fish only.

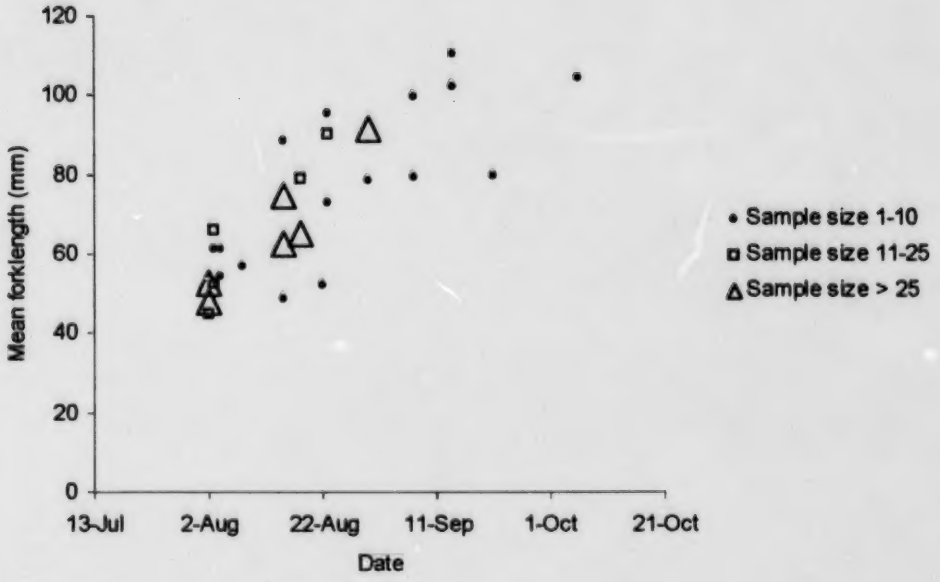

Figure 13. Mean forklengths of young-of-the-year striped bass collected in 2000.

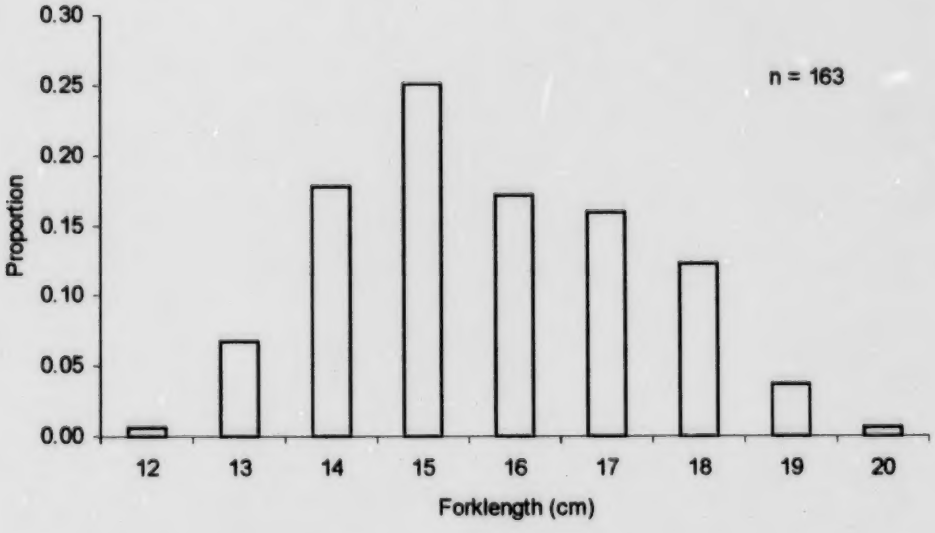

Figure 14. Forklength distribution of 0+ striped bass captured in smelt bagnets from waters adjacent to the Tabusintac River during November 1999.